

WE CLAIM:

1                   1.    A method of analyzing an orthodontic  
2    treatment comprising:  
3                    modeling first positions of a patient's teeth;  
4                    modeling desired second positions of the  
5    patient's teeth; and,  
6                    performing a finite element analysis based on  
7    the orthodontic treatment and a movement of the patient's  
8    teeth between the first and second positions.

1                   2.    The method of claim 1 wherein the  
2    performing of the finite element analysis comprises  
3    performing the finite element analysis based on a  
4    movement of the patient's teeth from the second positions  
5    to the first positions.

1                   3.    The method of claim 1 wherein the  
2    orthodontic treatment is based upon a set of orthodontic  
3    appliances to be applied to the patient's teeth, and  
4    wherein the performing of the finite element analysis  
5    comprises performing the finite element analysis based  
6    upon the set of orthodontic appliances and the movement

7 of the patient's teeth between the first and second  
8 positions.

1 4. The method of claim 3 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis based on a  
4 movement of the patient's teeth from the second positions  
5 to the first positions.

1 5. The method of claim 1 wherein the  
2 performing of the finite element analysis comprises:  
3 determining position vectors for each of the  
4 patient's teeth between the first and second positions;  
5 and,  
6 performing the finite element analysis based on  
7 the orthodontic treatment and a movement of the patient's  
8 teeth along the position vectors.

1 6. The method of claim 5 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis based on a  
4 movement of the patient's teeth from the second positions  
5 to the first positions.

1                   7.    The method of claim 5 wherein the  
2   orthodontic treatment is based upon a set of orthodontic  
3   appliances to be applied to the patient's teeth, and  
4   wherein the performing of the finite element analysis  
5   comprises performing the finite element analysis based  
6   upon the set of orthodontic appliances and the movement  
7   of the patient's teeth between the first and second  
8   positions.

1                   8.    The method of claim 7 wherein the  
2   performing of the finite element analysis comprises  
3   performing the finite element analysis based on a  
4   movement of the patient's teeth from the second positions  
5   to the first positions.

1                   9.    The method of claim 1 wherein the first  
2   positions of the patient's teeth are original positions,  
3   and wherein the second positions of the patient's teeth  
4   are final positions.

1                   10.   The method of claim 1 wherein the first  
2   positions of the patient's teeth are original positions,  
3   and wherein the second positions of the patient's teeth  
4   are intermediate positions.

1                   11. A method of determining an effective  
2                   orthodontic treatment comprising:

3                   a) creating a first model based upon first  
4                   positions of a patient's teeth;

5                   b) creating a second model based upon second  
6                   positions of the patient's teeth, wherein the second  
7                   positions represent desired positions of the patient's  
8                   teeth;

9                   c) selecting a proposed set of orthodontic  
10                  appliances according to a proposed orthodontic treatment;

11                  d) performing a finite element analysis based  
12                  on the proposed orthodontic treatment and a movement of  
13                  the patient's teeth between the first and second  
14                  positions;

15                  e) selecting a new set of orthodontic  
16                  appliances if the finite element analysis indicates that  
17                  the proposed orthodontic treatment produces undesired  
18                  effects; and,

19                  f) repeating d) and e) as necessary until the  
20                  effective orthodontic treatment is achieved.

1                   12. The method of claim 11 wherein the  
2 undesired effects include stresses and/or strains outside  
3 of a desired range.

1                   13. The method of claim 11 wherein the  
2 undesired effects include stresses and/or strains above  
3 or below an acceptable limit.

1                   14. The method of claim 11 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis based on the first  
4 and second models.

1                   15. The method of claim 11 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis based on a  
4 movement of the patient's teeth from the second positions  
5 to the first positions.

1                   16. The method of claim 11 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis in two stages,  
4 wherein the first stage determines wire deformation of  
5 archwires, and wherein the second stage determines

6 stresses, strains, forces, and /or moments as a result of  
7 the wire deformation.

1 17. The method of claim 11 wherein the  
2 performing of the finite element analysis comprises:

3 determining position vectors for each of the  
4 patient's teeth between the first and second positions;  
5 and,

6 performing the finite element analysis based on  
7 the orthodontic treatment and a movement of the patient's  
8 teeth along the position vectors.

1 18. The method of claim 11 wherein the  
2 creating of the first model includes displaying the first  
3 model.

1 19. The method of claim 18 wherein the  
2 selecting of a proposed set of orthodontic appliances  
3 comprises selecting the proposed set of orthodontic  
4 appliances based on the displayed first model.

1                   20. The method of claim 11 wherein the  
2                   selecting of a proposed set of orthodontic appliances  
3                   comprises installing the proposed set of orthodontic  
4                   appliances on the second model.

1                   21. The method of claim 20 wherein the  
2                   selecting of a proposed set of orthodontic appliances  
3                   comprises displaying the installed set of orthodontic  
4                   appliances on the second model.

1                   22. The method of claim 20 wherein the  
2                   creating of the first model includes displaying the first  
3                   model.

1                   23. The method of claim 22 wherein the  
2                   selecting of a proposed set of orthodontic appliances  
3                   comprises selecting the proposed set of orthodontic  
4                   appliances based on the displayed first model.

1                   24. The method of claim 20 wherein the  
2                   performing of the finite element analysis comprises  
3                   performing the finite element analysis in two stages,  
4                   wherein the first stage determines wire deformation of  
5                   archwires, and wherein the second stage determines

6 stresses, strains, forces, and /or moments on the  
7 proposed set of orthodontic appliances as a result of the  
8 wire deformation.

1 25. The method of claim 11 wherein the first  
2 positions of the patient's teeth are original positions,  
3 and wherein the second positions of the patient's teeth  
4 are final positions.

1 26. The method of claim 11 wherein the first  
2 positions of the patient's teeth are original positions,  
3 and wherein the second positions of the patient's teeth  
4 are intermediate positions.

1 27. A computer readable storage medium having  
2 program code stored thereon which, when executed by a  
3 computer, performs the following tasks:

4 a) storing a first position model of a  
5 patient's teeth;

6 b) storing a second position model of the  
7 patient's teeth, wherein the second position model  
8 represents desired positions of the patient's teeth;

9 c) storing a set of orthodontic appliances;



10                   d) applying the set of orthodontic appliances  
11                   to the patient's teeth according to one of the first and  
12                   second position models; and,

13                   e) performing a finite element analysis based  
14                   on the first position model, the second position model,  
15                   and the applied set of orthodontic appliances.

1                   28. The computer readable storage medium of  
2                   claim 27 wherein the performing of the finite element  
3                   analysis comprises displaying stresses, strains, forces,  
4                   and /or moments resulting from the applied set of  
5                   orthodontic appliances.

1                   29. The computer readable storage medium of  
2                   claim 27 wherein the storing of an original position  
3                   model comprises displaying upper and lower arches of the  
4                   patient.

1                   30. The computer readable storage medium of  
2                   claim 27 wherein the applying of the set of orthodontic  
3                   appliances comprises displaying the applied set of  
4                   orthodontic appliances on the patient's teeth.

1                   31. The computer readable storage medium of  
2 claim 27 wherein the performing of the finite element  
3 analysis comprises performing the finite element analysis  
4 based on a movement of the patient's teeth between  
5 original and final positions as represented by the  
6 original and final position models.

1                   32. The computer readable storage medium of  
2 claim 27 wherein the performing of the finite element  
3 analysis comprises performing the finite element analysis  
4 based on a movement of the patient's teeth from a final  
5 position to an original position as represented by the  
6 original and final position models.

1                   33. The computer readable storage medium of  
2 claim 27 wherein the applying of the set of orthodontic  
3 appliances comprises applying the set of orthodontic  
4 appliances to the patient's teeth according to the final  
5 position model.

1                   34. The computer readable storage medium of  
2 claim 27 wherein the performing of the finite element  
3 analysis comprises:

4                   determining position vectors for each of the  
5 patient's teeth between original and final positions as  
6 represented by the original and final position models;  
7 and,

8                   performing the finite element analysis based on  
9 the applied set of orthodontic appliances and a movement  
10 of the patient's teeth along the position vectors.

1                   35. The computer readable storage medium of  
2 claim 27 wherein the first position model represents  
3 original positions of the patient's teeth, and wherein  
4 the second positions of the patient's teeth are final  
5 positions.

1                   36. The computer readable storage medium of  
2 claim 27 wherein the first position model represents  
3 original positions of the patient's teeth, and wherein  
4 the second positions of the patient's teeth are  
5 intermediate positions.

1                   37. A method, implemented with the assistance  
2 of a computer, of determining an effective orthodontic  
3 treatment comprising:

4                   a) storing first positions of a patient's  
5 teeth;

6                   b) displaying the patient's teeth according to  
7 the first positions;

8                   c) selecting orthodontic appliances according  
9 to a proposed orthodontic treatment of the patient's  
10 teeth;

11                   d) storing second positions of the patient's  
12 teeth, wherein the second positions are desired  
13 positions;

14                   e) installing the selected orthodontic  
15 appliances on the patient's teeth in the second  
16 positions; and,

17                   f) performing a finite element analysis to  
18 assess effects on the orthodontic appliances and on the  
19 patient's teeth based on the first and second positions  
20 and on the proposed orthodontic treatment.

1           38. The method of claim 37 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis based on a  
4 movement of the patient's teeth from the second positions  
5 to the first positions.

1           39. The method of claim 37 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis based upon the set  
4 of orthodontic appliances and the movement of the  
5 patient's teeth between the first and second positions.

1           40. The method of claim 37 wherein the  
2 performing of the finite element analysis comprises:  
3           determining position vectors for each of the  
4 patient's teeth based on the first and second positions;  
5 and,  
6           performing the finite element analysis based on  
7 the proposed orthodontic treatment and a movement of the  
8 patient's teeth along the position vectors.

1           41. The method of claim 40 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis based on a  
4 movement of the patient's teeth from the second positions  
5 to the first positions along the position vectors.

1           42. The method of claim 37 wherein the  
2 performing of the finite element analysis comprises:  
3           determining position vectors for each of the  
4 patient's teeth between the first and second positions as  
5 represented by the first and second models;  
6           assigning material properties to the patient's  
7 teeth, PDL, and bone and to the proposed orthodontic  
8 treatment; and,  
9           performing the finite element analysis based on  
10 the proposed orthodontic treatment, the assigned material  
11 properties, and a movement of the patient's teeth between  
12 the first and second positions.

1           43. The method of claim 42 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis based on a  
4 movement of the patient's teeth from the second positions  
5 to the first positions.

1                   44. The method of claim 42 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis based on forces on  
4 the teeth exerted from deformed wire on the orthodontic  
5 appliances and based on the material properties of the  
6 teeth, PDL, and bone so as to predict a tooth movement  
7 path from original positions of the teeth.

1                   45. The method of claim 42 wherein the  
2 performing of the finite element analysis comprises  
3 displaying stresses, strains, forces, and /or moments on  
4 both the patient's teeth and the selected orthodontic  
5 appliances used in the proposed orthodontic treatment.

1                   46. The method of claim 37 wherein the  
2 performing of the finite element analysis comprises  
3 displaying stresses, strains, forces, and /or moments on  
4 both the patient's teeth and the selected orthodontic  
5 appliances used in the proposed orthodontic treatment.

1                   47. The method of claim 37 wherein the  
2 performing of the finite element analysis comprises  
3 performing the finite element analysis in two stages,  
4 wherein the first stage determines deformation of  
5 archwires, and wherein the second stage determines  
6 stresses, strains, forces, and /or moments on the  
7 proposed set of orthodontic appliances and on the  
8 patient's teeth as a result of the deformation.

1                   48. The method of claim 37 wherein the first  
2 positions of the patient's teeth are original positions,  
3 and wherein the second positions of the patient's teeth  
4 are final positions.

1                   49. The method of claim 37 wherein the first  
2 positions of the patient's teeth are original positions,  
3 and wherein the second positions of the patient's teeth  
4 are intermediate positions.